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# Soil Survey

of

# The Gallatin Valley Area, Montana

By

WILLIAM DeYOUNG

Montana Agricultural Experiment Station, in Charge

and

L. H. SMITH

United States Department of Agriculture

Bureau of Chemistry and Soils

In cooperation with the Montana Agricultural Experiment Station

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# SOIL SURVEY OF THE GALLATIN VALLEY AREA, MONTANA

By WILLIAM DE YOUNG, Montana Agricultural Experiment Station, in Charge, and L. H. SMITH
United States Department of Agriculture

## AREA SURVEYED

The Gallatin Valley area lies wholly within Gallatin County in southwestern Montana (fig. 1). Bozeman, the county seat of Gallatin County, is about 90 miles north of the west entrance of Yellowstone National Park and nearly 230 miles south of the Canadian border. The area surveyed covers 802 square miles, or approximately 30 percent of the total land area of the county, and includes most of the irrigated lands, together with much of the nonirrigated farming and grazing lands of the higher valley slopes or benches and the adjacent foothills that border the mountains. That part of the county outside of this area is largely mountainous. The largest bodies of nonirrigated land within the area are south of Three Forks and Willow Creek west of Madison River, north and west of Anceney, and north and east of East Gallatin River.

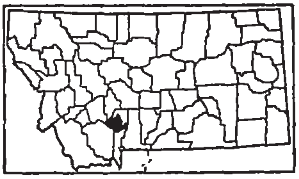

FIGURE 1.—Sketch map showing location of the Gallatin Valley area, Mont.

The Gallatin Valley area is one of the most important agricultural areas of the northern Rocky Mountain States. It occupies a basin partly enclosed by high mountains. Two rivers, Madison and Gallatin, flow through the area in a northerly and a northwesterly direction, respectively, and they join Jefferson River near Three Forks to form Missouri River. Jefferson River forms the northwestern boundary of the area.

Nearly one-half the area consists of stream bottoms. The largest body of bottom land is along Gallatin River about 7 miles north of Bozeman. The valleys of Gallatin River and its tributaries become narrower rather abruptly near Logan, and the river continues through the hills in a narrow gorge to join Madison and Jefferson Rivers. The Madison and Jefferson River Valleys range in width from 2 to 3 miles. They are separated from Gallatin Valley and from each other by somewhat higher land. High hills and benches occupy the northern and western parts of the area.

All the main streams that head in the mountains are fed by melting snow and are perennial. These streams, particularly Gallatin River and its larger tributaries, provide water both for domestic purposes and for irrigation. The maximum quantity of water is discharged during May and June, when the water from melting snow is augmented by spring rains. In the lower parts of the valley, many of the stream banks are poorly defined and the waters make their way

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through the gravel bottoms by a series of interlacing, meandering streams. Natural drainage in the lower lying sections is deficient in many places. A rather large area of poorly drained land borders East Gallatin River north of Belgrade and Central Park. The deficient drainage is owing in part, perhaps, to a rising water table which has developed since irrigation began on the higher lands to the south, although early settlers state that the water has always been high in much of this section. In other places, seepage from the mountains has given rise to some poorly drained lands, particularly bordering Reese Creek. Some progress has been made in lowering the water table in the lower parts of the valley by the excavation of a few roadside ditches. It is probable that with some study greater alleviation may be obtained by a few larger and deeper drainage canals nearer the source of the ground water.

Geologists describe the Gallatin Valley as a former lake bed which probably existed during late Tertiary times.[1] It is stated that, following the formation of the lake in the valley, immense showers of fine volcanic dust, probably wind-borne, fell upon the surface of the lake and upon the land. This resulted in the deposition of lake-bottom sediments reaching a thickness of more than 2,000 feet. Most of the sediments are fine grained, and they have furnished the parent material for the greater part of the present soils. Since deposition of this material and the formation of an outlet for the release of the impounded waters, considerable surface erosion and cutting by the streams have taken place.

The territory south of Willow Creek and Three Forks rises to the south in successive benches toward the foothills of the Madison Range. The most conspicuous steeply eroded area borders Madison Valley west and north of Anceney. In this section the bench lands rise to the east more than 600 feet above the river. East of Madison Valley toward Anceney and Amsterdam, rather deep drainageways have cut into the former plain, causing a rolling surface relief. The central part, or floor, of the Gallatin Valley has the appearance of a gently sloping plain. To the south and east, rolling hills merge with the mountains. These hills are rather thoroughly dissected by many streams heading in the Gallatin and Bridger Ranges. Outwash fans, composed mostly of gneissic material, spread out from the foothills near the mountains.

The Gallatin Valley is a rather high intermountain area, in which wide differences in elevation exist between the lower parts of the valley and the higher benches and foothills and the surrounding mountain peaks. The lowest elevation is near the confluence of Gallatin, Madison, and Jefferson Rivers—about 4,000 feet above sea level. The higher areas that are being farmed lie at an elevation of about 5,800 feet. North of Menard the dry-farmed areas extend to an elevation of nearly 6,000 feet. The benches south of Three Forks and Willow Creek rise from about 4,200 to 5,200 feet near the Madison County line. South of Bozeman, there is a rather large body of irrigated land ranging from 5,000 to 5,600 feet in elevation, but north and west of Bozeman, the irrigated lands have an elevation of less than 5,000 feet. Many of the nearby mountain peaks rise from 3,000

[1] PEALE, A. C. THREE FORKS FOLIO, MONTANA. U. S. Geol. Survey, Geologic Atlas of the United States, Folio 24: 5, illus. 1896.

to 4,000 feet above the valley. The higher peaks of the Bridger Range have an elevation above sea level of about 9,000 feet, and the higher peaks of the Gallatin Range to the south average between 10,000 and 11,000 feet.[2]

Because of rather wide variations in climate and terrain within rather short distances in the Gallatin Valley, the distribution of the plants making up the vegetal cover is rather complex. Around the eastern and southern boundaries of the area an increase in elevation and nearness to the mountains causes an increase in annual precipitation which is accompanied by a more abundant plant growth.

Between elevations of 5,400 and 6,000 feet, which occur just north of the area surveyed, the open grassland cover of the higher hills and benches is replaced by a growth of brush and evergreen timber. A dense growth of small Douglas fir (*Pseudotsuga douglasi*) occurs in most places on the northern and eastern exposures of the mountain slopes and a more sparse cover of fir, Colorado juniper (*Juniperus scopulorum*), and brush of various kinds on the south and west slopes. For some distance below this zone, many mountain shrubs and herbs are mingled with the grass and sagebrush cover of the lower benches and the valley floor. The more abundant and conspicuous of these plants are the balsam-root (*Balsamorhiza sagittata*); sticky geranium (*Geranium viscosissimum*); western wild bergamot (*Monarda menthaefolia*) locally known as "horsemint"; wild salsify (*Tragopogon porrifolius*); several lupines; and a number of *Potentillas*.

Groves of cottonwood, both the common western species and the narrow-leaved mountain species, border the major stream channels, together with some dense thickets of willows, as well as black haw, red haw, chokecherry, service berry, and red-osier dogwood (*Cornus stolonifera*). Most of the intermittent drainage courses of the higher parts of the area are choked with a dense growth of the same species. Wild rose and western snowberry (*Symphoricarpus occidentalis*), commonly known as buckbush, are very common, generally bordering the roads, old ditch or canal banks, and stream and coulee bottoms in the more moist sections and extending westward and northward in favored locations in the arid sections. The common sagebrush (*Artemisia tridentata*) originally covered most of the uplands of the more arid sections, and it is still a dominant plant on the more eroded slopes and the rough lands.

The native-grass associations have become modified and confused with the introduced grasses since settlement and irrigation. Previous to settlement and irrigation, a moderate growth of silver (white) sagebrush (*Artemisia cana*) and an abundant grass growth covered the open hill slopes, benches, and parts of the lower lands of the eastern and southern subhumid sections of the area. A thick stand of the dominant grass association, consisting principally of bluebunch (Idaho) fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), junegrass (*Koeleria cristata*), with some western wheatgrass (*A. smithii*), slender wheatgrass (*A. pauciflorum*), and other less abundant species is still growing on the unplowed hill lands above the influence of irrigation. Introduced species of the cultivated grasses, principally Kentucky bluegrass and common timothy, have become

[2] Elevations taken from United States Geological Survey topographic survey and railroad folder.

widely distributed and have completely replaced the native grasses in many places.

On the uplands in the more arid country to the west and northwest are plant associations consisting of the more drought-resistant species, such as needlegrass (*Stipa comata*), wire grass (*Artistida longiseta*), niggerwool (*Carex filifolia*), bunch grass or little bluestem (*Andropogon scoparius*) and blue grama (*Bouteloua gracilis*). A scattered growth of rabbitbrush (*Chrysothamnus sp.*) is associated with these grasses in most places.

On the seeped alkaline lands north of Central Park the saltgrasses (*Distichlis spicata* and *Puccinellia nuttaliana*) are dominant. Downy chess (*Bromus tectorum*), locally known as military grass, and squirreltail grass, or wild barley, are regarded as weeds, as the seeds are injurious to livestock. Chess (*Bromus secalinus*) and so-called "false quackgrass" (*Agropyron pseudorepens*) have been introduced and are becoming abundant. Many other weeds have gained a foothold in the Gallatin Valley, and several of the more noxious ones, particularly the Canada thistle, have become so well established as to menace cultivation on the irrigated lands. On the more arid nonirrigated lands which are being used for wheat production, pennycress (*Thlaspi arvense*) locally known as fanweed, Russian-thistle, "Jim Hill" mustard, tansymustard (*Sophia incisa*), and skeletonweed are serious weed pests.

Gallatin County was created on February 2, 1865. It was one of the nine original counties formed in the Territory of Montana. Although fur traders and trappers had passed through the Gallatin Valley many years previously, it was not until after the years 1861–62, when the discovery of gold was made known to the outside world, that permanent settlers came to this area. The first agricultural settlements appear to have been made along East Gallatin River and Reese Creek. The first house in Bozeman was built in 1864. Many of the early settlers came from the mining district around Virginia City, perhaps because of disappointment in their quest for gold. They realized, however, the opportunity of supplying the mining camps with agricultural products, which at that time were hauled long distances to the camps. Many of these people originally came from Missouri, Kentucky, and Tennessee. A settlement of Hollanders was established west of Belgrade and south of Manhattan when irrigation was started in that section about 1890.

According to the 1930 census, the total population of Gallatin County is 16,124, of which 5,937 people are rural farm and 3,332 are rural nonfarm. There are 14,792 native whites, 1,845 of whom are of foreign parentage and 1,604 of mixed parentage. Bozeman, the county seat, with a population of 6,855, is located in the southeastern part of the area. Belgrade, Manhattan, Three Forks, Gallatin Gateway, and Willow Creek are important trading centers in the valley.

The main line of the Northern Pacific Railway crosses the area from east to west, and the main line of the Chicago, Milwaukee, St. Paul & Pacific Railroad serves the northern and western parts. Branch lines of both railways serve agricultural communities as

freight lines, whereby agricultural products may be shipped either to the Pacific coast or to the Twin Cities and Chicago.

The main public roads are well improved. A transcontinental highway, United States Highway No. 10, crosses the area. Bozeman and Gallatin Gateway are important entrances to Yellowstone National Park. Montana State College of Agriculture and Mechanic Arts and Montana Agricultural Experiment Station are located at Bozeman. The area is well supplied with grade and high schools, as well as churches of several denominations.

Flour mills are operated at Belgrade and Bozeman. In addition, a pea and bean canning plant and seed houses handling seed peas are local industries of importance.

## CLIMATE

The climate of the Gallatin Valley in general is similar to that of other intermountain valleys of the Northwest. It is continental in character and is subject to wide extremes of seasonal and daily temperatures, a difference of 30° F. sometimes occurring within 24 hours. Winds are variable in both movement and direction; in the daytime the winds may be prevailingly from the west or southwest, and at night they very often shift to the southeast. Locally some of the coldest winds in winter are from the east. During the winter, warm "chinook" winds are also of variable occurrence, at times causing the sudden disappearance of snow by direct evaporation.

The mean annual temperature at the agricultural college at Bozeman is 41.4° F., and at Three Forks is 42.5° F. Extreme periods of cold weather (−20° to −30°) are seldom of a week's duration. Although very hot days occur frequently during the summer, the nights are invariably cool and pleasant. The temperatures of either the hot days of summer or the intense cold periods of winter are not so severe as the same temperatures in the more humid parts of the United States, probably because of differences in atmospheric pressure, humidity, or both.

The last killing frost may be expected the latter part of May; however, it may occur considerably earlier or even as late as the latter part of June. The first killing frost generally occurs about the middle of September, but it has been known to occur early in August at Three Forks and about the middle of July at Bozeman. The average frost-free season extends over a period of 114 days at Bozeman and 102 days at Three Forks. Tables 1 and 2 give the normal monthly, seasonal, and annual temperature and precipitation at Bozeman and at Three Forks, which are located in the southeastern and northwestern parts of the valley, respectively.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at the agricultural college, Bozeman, Gallatin County, Mont.*

[Elevation, 4,900 feet]

| Month | Temperature | | | Precipitation | | | |
|---|---|---|---|---|---|---|---|
| | Mean | Absolute maximum | Absolute minimum | Mean | Total amount for the driest year (1919) | Total amount for the wettest year (1880) | Snow, average depth |
| | °F. | °F. | °F. | *Inches* | *Inches* | *Inches* | *Inches* |
| December | 22.6 | 60 | −27 | 1.00 | 1.33 | 0.75 | 10.6 |
| January | 19.5 | 65 | −53 | .85 | .51 | .63 | 10.8 |
| February | 22.0 | 66 | −53 | .81 | .78 | 1.40 | 8.2 |
| Winter | 21.4 | 66 | −53 | 2.66 | 2.62 | 2.78 | 29.6 |
| March | 29.9 | 75 | −36 | 1.24 | .65 | .54 | 13.6 |
| April | 42.2 | 82 | −16 | 1.71 | .96 | 1.04 | 6.7 |
| May | 49.0 | 94 | 15 | 3.41 | 2.10 | 12.26 | 2.4 |
| Spring | 40.4 | 94 | −36 | 6.36 | 3.71 | 13.84 | 22.7 |
| June | 57.1 | 99 | 26 | 2.97 | .09 | 7.35 | .0 |
| July | 64.0 | 104 | 29 | 1.31 | .36 | 3.61 | .0 |
| August | 62.7 | 112 | 29 | 1.02 | .97 | 1.25 | .1 |
| Summer | 61.3 | 112 | 26 | 5.30 | 1.42 | 12.21 | .1 |
| September | 53.0 | 97 | 26 | 1.71 | .87 | 1.20 | 1.1 |
| October | 43.4 | 85 | 18 | 1.35 | 1.81 | 1.50 | 5.2 |
| November | 31.3 | 71 | −4 | .97 | .59 | 1.10 | 10.9 |
| Fall | 42.6 | 97 | −4 | 4.03 | 3.27 | 3.80 | 17.2 |
| Year | 41.4 | 112 | −53 | 18.35 | 11.02 | 32.63 | 69.6 |

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Three Forks, Gallatin County, Mont.*

[Elevation, 4,400 feet]

| Month | Temperature | | | Precipitation | | | |
|---|---|---|---|---|---|---|---|
| | Mean | Absolute maximum | Absolute minimum | Mean | Total amount for the driest year (1899) | Total amount for the wettest year (1915) | Snow, average depth |
| | °F. | °F. | °F. | *Inches* | *Inches* | *Inches* | *Inches* |
| December | 21.1 | 61 | −43 | 0.48 | 0.51 | 0.70 | 4.4 |
| January | 21.7 | 64 | −40 | .25 | .40 | .28 | 2.8 |
| February | 24 2 | 67 | −45 | .35 | .90 | .02 | 3.9 |
| Winter | 22.3 | 67 | −45 | 1.08 | 1.81 | 1.00 | 11.1 |
| March | 33.1 | 79 | −24 | .39 | .36 | .97 | 3.8 |
| April | 43.5 | 83 | 8 | .94 | .46 | .57 | 2.6 |
| May | 51.8 | 95 | 18 | 1.63 | .18 | 1.81 | .6 |
| Spring | 42.8 | 95 | −24 | 2.96 | 1.00 | 3.35 | 6.5 |
| June | 59.8 | 100 | 28 | 1.91 | 1.40 | 4.43 | (1) |
| July | 65.5 | 102 | 29 | .99 | .02 | 2.53 | .0 |
| August | 63.6 | 97 | 20 | .68 | .55 | 1.00 | (1) |
| Summer | 63.0 | 102 | 20 | 3.58 | 1.97 | 7.96 | .0 |
| September | 53.1 | 92 | 18 | 1.24 | .16 | 2.66 | .4 |
| October | 42.6 | 83 | −9 | .86 | 1.05 | .12 | 2.4 |
| November | 30.2 | 68 | −37 | .53 | .25 | .63 | 3.8 |
| Fall | 42.0 | 92 | −37 | 2.63 | 1.46 | 3.41 | 6.6 |
| Year | 42.5 | 102 | −45 | 10.25 | 6.24 | 15.72 | 24.2 |

[1] Trace.

The average annual precipitation at Bozeman is 18.35 inches, much of which comes in the form of snow, the average annual snowfall being nearly 70 inches. The color of the surface soils and the character of the vegetation indicate considerable decrease in precipitation both to the north and west of Bozeman. This is substantiated by incomplete records obtained near Three Forks and at Ennis in Madison County, where the average annual precipitation is approximately 10 inches.

The Gallatin Range to the south of Bozeman and to less extent the Bridger Range on the east border of the valley seem to influence or control many local showers, especially during the summer. Hailstorms are of infrequent occurrence but may do much damage to crops. The greater part of the annual rainfall comes during late spring and early summer. May and June are normally the months of heaviest rainfall.

The large amount of snowfall in the mountains to the south is particularly advantageous to a large part of the valley, because of the supply of water furnished thereby for irrigation and domestic purposes.

Evaporation records at Bozeman show a variation from 33.3 inches to 46.7 inches for the months of April to October, inclusive. These records show a somewhat lower evaporation than for much of the plains area.

## AGRICULTURAL HISTORY AND STATISTICS

The agricultural history of the Gallatin Valley began soon after the opening of the mines near Virginia City and at other points in western Montana. The greatest activity in the mining section began in 1862 and 1863. It was almost immediately recognized that there was an opportunity for growing foodstuffs and supplying the mining camps with these products which at first were hauled into the State from distant points. Records of the State Historical Society show that residents of the Gallatin Valley marketed potatoes and other vegetables at Virginia City in the fall of 1864. In the main, however, the interests of the early settlers were centered in raising livestock—cattle and horses, with a few bands of sheep—on the range. It was found that cereals could be grown in the valley, and a flour mill was built near Bozeman in the fall of 1864. Timothy, redtop, and native bunch grasses were the early forage crops grown.

It was not until 1885, when the Northern Pacific Railway reached Bozeman, that rapid development of the agricultural lands of the valley began. The population of Gallatin County was 1,578 in 1870 and by 1900 had reached 9,553. Nearly one-half of the total production of wheat and oats in the Territory of Montana in 1870 was in Gallatin County.

Table 3 gives data taken from the United States census reports for the county, showing the development of farm land since 1880.

TABLE 3.—*Total area, number, size, and tenure of farms in Gallatin County, Mont., in stated years*

| Year | Farms | Total area in farms | Percentage of county in farms | Average size of farms | Improved land per farm | Farms operated by— | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Owners | Tenants | Managers |
| | *Number* | *Acres* | *Percent* | *Acres* | *Percent* | *Percent* | *Percent* | *Percent* |
| 1880 | 175 | 53,337 | ---------- | 305.0 | 62.8 | 99.1 | 0.9 | 0.0 |
| 1890 | 587 | 200,367 | 12.5 | 341.0 | 63.5 | 92.7 | 7.3 | .0 |
| 1900 | 950 | 368,706 | 22.9 | 388.1 | 46.7 | 78.5 | 19.8 | 1.7 |
| 1910 | 1,260 | 531,902 | 33.1 | 422.1 | 52.6 | 75.4 | 22.9 | 1.7 |
| 1920 | 1,349 | 783,189 | 48.8 | 580.6 | 44.8 | 71.5 | 26.5 | 2.0 |
| 1930 | 1,336 | 722,657 | 45.3 | 540.9 | 42.8 | 58.9 | 39.1 | 2.0 |

The 1930 census reports that in 1929 crops were harvested from 172,208 acres, crop failure occurred on 6,956 acres, 85,246 acres were idle or fallow land, 45,373 acres in plowable pasture, 51,968 acres in woodland pasture, 319,012 acres in other pasture land, 4,235 acres in woodland not pastured, and 37,659 acres in all other land.

Gallatin County has a land area of about 1,595,520 acres, of which about 68 percent is mountainous and largely included in the national forest reserve. The area included in this soil survey comprises about 30 percent of the total land area and includes the greater part of the farming lands.

Most of the tenant-operated farms are leased on a share-crop basis, the proportion of the crops received by tenant and owner depending on the amount of machinery, livestock, and seed provided by the landlord.

The principal crops produced in the Gallatin Valley have been about the same since 1880, although the importance of the various crops and their acreage has changed from time to time. Wheat always has been an important cash crop. Since 1910, a large though variable acreage of the dry or nonirrigated land has been devoted to this crop. In 1929, about 45 percent of the total cropped acreage in the county was used for wheat. Of the 78,311 acres in wheat, 61.3 percent, or 48,057 acres, were in winter wheat, and 30,254 acres were planted to spring wheat. The average acre yield was approximately 17 bushels. The irrigable acreage devoted to the growing of wheat, however, has declined during the last few years.

Since 1910, the importance of the oats crop has declined considerably. In 1910, 37,676 acres, or 27 percent of the total cropped acreage, was devoted to oats, whereas in 1929, only 13,040 acres, or about 7 percent, of the cropped land was used thus.

Barley reached its greatest importance in 1900. When the malting mills closed, the demand for this crop decreased greatly. In 1929, about 6 percent of the total cropped acreage was used for barley.

Alfalfa has been grown on an increasingly larger acreage since1900. In 1929, 30,088 acres, or 17 percent of the total cropped acreage, produced this crop. Alfalfa has largely replaced the clover and timothy formerly grown on the irrigated lands, as well as much of the wild hay, because of the greater tonnage produced.

A small aggregate acreage of wild grasses is cut for hay, also some grains in the dry-land sections. Both seed and canning peas have become important local crops for the southern part of the Gallatin

Valley. The estimated area devoted to these crops in 1930 was about 15,000 acres. Intertilled crops have played a very minor role in the agriculture of this area. About 500 acres are devoted to the growing of potatoes, some of which are sold for certified seed. Small acreages are devoted to sugar beets, beans, and other vegetables.

Table 4 shows the acreage of the principal crops in Gallatin County in 1879, 1889, 1899, 1909, 1919, and 1929.

TABLE 4.—*Acreage of principal crops in Gallatin County, Mont., in stated years*

| Crop | 1879 | 1889 | 1899 | 1909 | 1919 | 1929 |
|---|---|---|---|---|---|---|
| | *Acres* | *Acres* | *Acres* | *Acres* | *Acres* | *Acres* |
| Wheat, total | 5,301 | 8,066 | 25,173 | 47,186 | 62,197 | 78,311 |
| Winter wheat | | | | | | 48,057 |
| Spring wheat | | | | | | 30,254 |
| Oats for grain | 4,730 | 9,723 | 18,975 | 37,676 | 9,598 | 18,040 |
| Oats cut green | | | | | | 347 |
| Barley | 245 | 3,378 | 16,458 | 4,884 | 3,535 | 10,201 |
| Rye | | | 372 | 964 | 500 | 377 |
| Potatoes | | 171 | 424 | 879 | 500 | 505 |
| Peas (dry) | | | 1 | 51 | 5,229 | 284 |
| Hay, all kinds | 5,112 | 17,206 | 31,989 | 46,730 | 50,994 | 54,100 |
| Alfalfa | | | 2,297 | 11,215 | 19,811 | 30,088 |
| Sweetclover for pasture | | | | | | 829 |
| Clover | | | 1,223 | 8,444 | 4,107 | 2,556 |
| Timothy or timothy and clover | | | | 16,060 | 17,496 | 14,248 |
| Wild grasses | | | 17,894 | 7,018 | 4,130 | 5,000 |
| Small grains for hay | | | 1,583 | 1,274 | 2,270 | 515 |
| Sugar beets | | | | | | 28 |
| Peas for canning | | | | | | 2,092 |

The use of soil amendments, other than stable manure, is practically unknown, although interest in commercial fertilizers is beginning to appear. In 1929, only four farms reported the use of fertilizers and manure with a total value of $1,050.

Labor is generally adequate except during the harvest season. A part of the labor used during the rush periods comes from the floating population, and during this time wages ranging from $3 to $4 a day are paid. Labor on the general farms is hired by the month at a rate ranging from $40 to $60, including board. Seed peas, canning peas, canning beans, and sugar beets are grown under contract with the various companies handling these products, and much of the labor is provided by the companies concerned.

As the Gallatin Valley is one of the oldest agricultural areas in the State, there have been erected many fine farm dwellings as well as other farm buildings. The barns and sheds are generally adequate for the housing of dairy and beef cattle and the smaller herds of sheep. Most farmers own practically all types of modern machinery, such as tractors, mowers, binders, and combine harvesters, together with numerous tillage implements. Since the introduction of the tractor, the number of horses has decreased greatly.

When this country was first settled, livestock raising was the leading pursuit, and during the first quarter of a century, livestock continued to be the chief source of income. Within the last 25 years the relationship between the values of livestock and crops produced has been changing. In 1929 the value of crops produced was $3,553,065, and the value of livestock and livestock products was $3,998,907.

The first settlers engaged in cattle ranching, and cattle were brought into the county in large numbers. As early as 1866, Nelson Story

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came over the Bozeman Trail to the Gallatin Valley with a herd of 600 Texas longhorns purchased in Dallas. For a number of years following, cattle roamed over the valleys and mountain ranges in large herds. Only a small quantity of feed was produced for wintering them, and they were largely dependent on the native vegetation.

There are now only a few large cattle outfits, and many of the cattle are run in small numbers on irrigated ranches. During the summer the large outfits graze their cattle on the national-forest or privately owned range land. The average length of the grazing period on the national forest is from June 1 to October 15, or approximately 137 days. Much of the grazing land is under fence, and the cattlemen have definite areas on which to graze their cattle. The general practice is to feed the cattle during severe winter weather.

Gallatin County is the home of nationally known herds of purebred cattle, the Hereford and Shorthorn breeds being particularly well represented. The cattle of the large outfits are of fine-quality beef breeds, but many of the cattle on the irrigated farms are of inferior breeding and quality, and they show a lack of attention in the selection of breeding stock.

Most of the cattle shipped out are sold as yearlings and 2-year-olds. Some of them class as fat livestock, and others sell as feeders. In recent years there has been a growing tendency to fatten more of the cattle before sending them to market. In 1930, 257 carlots of cattle were shipped out.

Sheep rank second in total numbers, being exceeded only by beef cattle. Unlike cattle, sheep were of comparatively minor importance in the early history of the county, but during the last quarter of a century the difference in numbers between sheep and cattle has been markedly narrowed. Most of the sheep owned by the farmers in this county are included in what may be termed farm flocks. It is true that a considerable area of the national-forest and privately owned range land is used for summer grazing of sheep, but most of these sheep are owned by operators located in adjoining counties and are here only for the summer-grazing period.

Many of the farm flocks are purebreds and are maintained for the sale of breeding stock, which is the chief source of income for the sheepmen. Under this system the sheep remain on the farm during the entire year. They are run on irrigated pasture in the summer and fed during the winter. Sufficient feed for wintering sheep, including alfalfa hay and one or more of the small grains, is generally produced on the farms. The Hampshire is the most popular breed for farm flocks, but there are a few flocks of some other mutton breed. Several breeders of purebred Rambouillet sheep of national prominence are located here. In contrast with the Hampshire farm flocks, the Rambouillets are run in large bands and are grazed on the range during the summer. Such purebred herds maintained for sale of breeding stock are given a fairly liberal winter ration.

In 1930, 106 carlots of sheep and 10 carlots of wool were shipped out of the county. Practically the entire wool clip was shipped through the local wool pool. In 1929, there were 401,672 pounds of wool produced, with an estimated value of $124,518.

Hogs are raised on most of the irrigated ranches, frequently in combination with dairy cattle. Although there are few, if any, strictly hog outfits, hogs are kept by many ranchmen to utilize un-

marketable grain. Most of the hogs are of good breeding and fair quality, showing that some attention has been given to the selection of breeding stock. There are several purebred herds, some of them of very good type. On many farms, the hogs are allowed to run in the fields after the crops have been harvested. The principal hog feeds are wheat and barley, supplemented with skim milk and alfalfa pasture or hay. In 1929, there were 13,345 hogs in the county, with an estimated value of $148,716. In 1930, 127 car lots of hogs were shipped out, practically all of which went to the western markets, owing to the more attractive prices paid for hogs on the coast markets as compared to those of the Corn Belt markets. This advantage tends to make hog production more attractive than it otherwise would be.

Prior to 1900, dairying was of no commercial importance, but since that time there has been a gradual increase in the number of dairy cows. With the exception of a few herds that supply whole milk for city trade, dairying continues to be a minor enterprise on most ranches. It is probably due to this fact that the dairy herds are small, most of them numbering less than 20 head, and that little special attention is given to the care and management of the dairy cows, such as is done in the older dairy sections of the country. Many of the barns and sheds provided for housing purposes, although substantial, are rather plain, and very little high-priced dairy equipment is used. During the summer the cows are run on irrigated or lowland native pastures. Practically all the necessary feed is produced on each ranch. Common home-grown feeds, such as alfalfa and small grains, make up the greater part of the feed. The first herd of purebred dairy cattle was established about 1908. Holstein-Friesians are the leading breed, followed by Guernseys and Brown Swiss. A very outstanding herd of Brown Swiss cattle has been developed, which has become nationally known and has done much toward advertising Gallatin County.

There are 4 creameries in the county, 2 at Bozeman, 1 at Manhattan, and 1 at Three Forks. Cheese factories are located at Central Park, Gallatin Gateway, and Sedan. There are 3 cream-receiving stations in Bozeman, 2 in Belgrade, 2 in Manhattan, and 1 in Willow Creek.

Most farms maintain a small flock of poultry usually consisting of chickens, turkeys, and ducks or geese, the returns from which often pay for the cost of feeding the farmer's family. In 1929, the value of the poultry produced, including chickens, turkeys, ducks, and geese, was $145,121. During this year the value of chicken eggs produced was $193,125.

Table 5 gives the number and value of livestock in the county in 1920 and 1930.

TABLE 5.—*Number and value of domestic animals, poultry, and bees in Gallatin County, Mont., in 1920 and 1930*

| | 1920 | | 1930 | | | 1920 | | 1930 | |
|---|---|---|---|---|---|---|---|---|---|
| | *Number* | *Value* | *Number* | *Value* | | *Number* | *Value* | *Number* | *Value* |
| All cattle | 35,635 | $2,167,816 | 32,574 | $1,785,623 | Chickens | 82,143 | [1] $78,677 | 83,518 | $60,968 |
| Sheep | 25,213 | 345,482 | 78,135 | 563,751 | Horses | 16,782 | 1,289,151 | 10,438 | 354,165 |
| Swine | 11,504 | 192,483 | 13,345 | 148,716 | Bees (hives) | 177 | 1,504 | 1,582 | 10,758 |

[1] All poultry.

## SOILS AND CROPS

The soils of the Gallatin Valley area may be divided into three general groups, namely, well-drained farming soils, imperfectly drained farming soils, and nonagricultural soils. The well-drained farming soils may in turn be divided into three subgroups, based on the color of the surface soils, namely, dark-colored soils, brown soils, and light-brown or grayish-brown soils. These are the normally developed soils. This grouping according to color correlates, in general, with the content of organic matter in the various soils and also with the relative distribution of annual precipitation over the area as a whole, under the influence of the mountains.

Figure 2 shows the distribution of the three subgroups of well-drained farming soils.

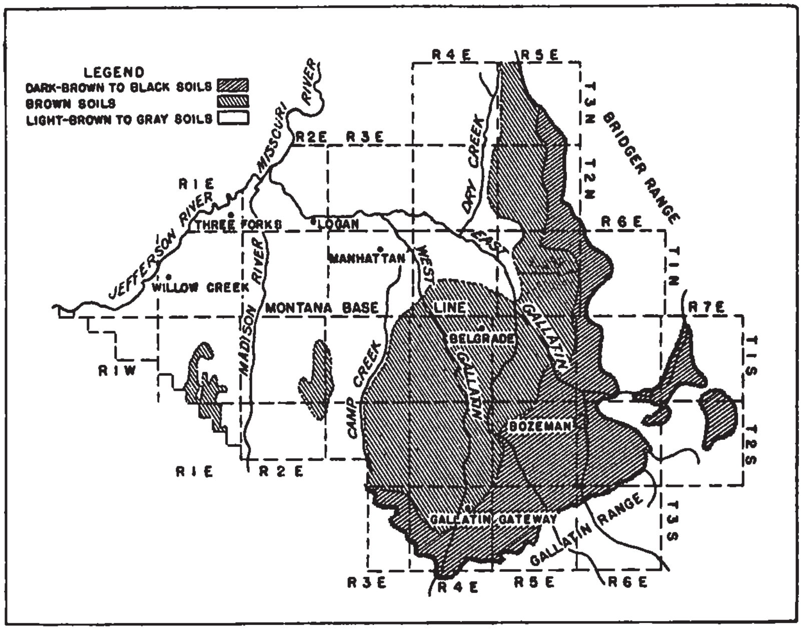



FIGURE 2.—Sketch map of the Gallatin Valley area, Mont., showing the three subgroups of well-drained farming soils. Note that the dark-brown to black soils lie adjacent to the mountain ranges.

The normal dark-colored soils occur only in an area bordering the Gallatin and the Bridger Ranges on the southern and eastern borders of the area. These soils occupy the foothills or mountain slopes and the southeastern part of the valley floor, where precipitation is higher than in other parts of the area. Much of this dark-soil belt is so situated that irrigation is possible, at least during the spring run-off.

The topsoils of these soils range in color from dark brown to black and in texture from coarse loam to silty clay, but they are dominantly silty. The darkest soils occur at the higher elevations or in those areas in which the accumulation of organic matter is favored. The Bridger soils are characterized by rather coarse textured surface soils and porous subsoils, which generally contain many fragments of gneiss and schist. These soils occupy the higher mountain slopes and outwash fans. In general they contain little or no free lime

within a depth of 3 feet, and they may be slightly acid in reaction at the surface.

The soils of the Bozeman series contain no gravel, at least to a depth of 6 feet. They are silty soils, presumably wind-blown or loess material of local origin. The soils of the Millville series are underlain by gravel.

The brown soils occur largely in an area bordering the dark-colored soils at a somewhat greater distance from the mountain ranges and generally at a lower elevation. They occupy an area that receives a lower amount of annual precipitation, as compared with the soils of the dark-soil belt. The brown-soil group may be subdivided according to texture into silty soils, including a brown phase of the Bozeman soil, the Amsterdam soils, and the loamy and gravelly soils of the Beaverton series. The loamy and gravelly soils naturally have a somewhat lower moisture-holding capacity than the former because of their more open character. The beginning of the lime zone ranges in depth from 10 to 20 inches beneath the surface.

The light-brown soils are largely determined by the comparatively low annual precipitation. Practically all the Gallatin Valley area soils west of Camp and Dry Creeks, except those at the higher elevations, have a low organic-matter content and are light in color. They range from fine sand to silt loam in texture. The lime horizon ranges in depth below the surface from 6 to 12 inches. The land occupied by these soils is largely a grazing and dry-farming territory, except the areas that may be irrigated, as in the Manhattan district, and small bodies bordering Jefferson River and Willow Creek and in the Madison River Valley.

All the imperfectly drained soils are of alluvial origin and border the main streams. The largest areas border East Gallatin River. Areas having a high water table occur in both the Madison River and Jefferson River Valleys. The imperfectly drained soils range in color from nearly black to gray, depending on local drainage conditions, accumulation of organic matter, the height of the ground-water table, and the accumulation of alkali salts.

The nonagricultural soils consist of river wash materials, which border the major stream courses, and rough broken and mountainous land.

Two types of farming, based largely on the availability of water for irrigation, are carried on within the Gallatin Valley area, namely, irrigation farming and nonirrigation, or dry, farming. On some farms a part of the farm or ranch may be irrigated and the rest dry farmed or used for grazing.

The growing of certain crops, such as alfalfa, peas, or sugar beets, depends on an available moisture supply, either from irrigation, subirrigation, or favorable location with respect to rainfall. In the growing of cereal crops, more particularly wheat, there is a wider range of adaptability, and wheat is grown to some extent on most of the soils. In general, however, this crop is now grown more largely under dry-farming conditions on an extensive scale. When grown on the irrigated lands, it is used mainly as a step in the crop rotation.

The agriculture of the irrigated areas is largely built around the production of forage crops, mainly alfalfa, alternated with grains produced for feed. These enterprises include the raising of livestock

as an important or major part of the business. Locally, dairying is important. Seed peas and canning peas are crops of special importance in the Bozeman district.

The nonirrigated sections depend almost entirely on the growing of wheat, and the rough untillable areas are used solely for grazing. Where advantageous a combination of irrigated land for hay production and a rather large acreage of grazing land provides facilities for an ideal livestock ranch. The tillable areas at the higher elevations have been used largely for the growing of winter wheat. Winterkilling, however, has become a factor in lessening the quantity of winter wheat grown in recent years.

In the following pages the different soils indicated on the accompanying map are described, their relation to one another is shown, and their influence on the agricultural development and farming practices of the area is discussed. Table 6 shows the acreage and proportionate extent of the soils.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in the Gallatin Valley area, Mont.*

| Type of soil | Acres | Per cent | Type of soil | Acres | Per cent |
|---|---|---|---|---|---|
| Bridger loam | 28,224 | 5.5 | Ashuelot gravelly loam | 9,856 | 1.9 |
| Bridger gravelly loam | 9,088 | 1.8 | Beaverton gravelly loam | 16,000 | 3.1 |
| Bridger stony loam | 6,720 | 1.3 | Beaverton loam | 17,984 | 3.5 |
| Bridger silty clay loam | 5,120 | 1.0 | Beaverton loam, dark-colored phase | 4,224 | .8 |
| Bozeman silt loam | 6,848 | 1.3 | Huffine silt loam | 10,752 | 2.1 |
| Bozeman silt loam, brown phase | 15,936 | 3.1 | Huffine silt loam, poorly drained phase | 4,288 | .8 |
| Amsterdam silt loam | 40,192 | 7.8 | Huffine gravelly loam | 2,368 | .5 |
| Amsterdam very fine sandy loam | 14,464 | 2.8 | Gallatin silty clay loam | 4,736 | .9 |
| Manhattan very fine sandy loam | 52,352 | 10.2 | Gallatin silt loam | 16,192 | 3.2 |
| Manhattan very fine sandy loam, colluvial phase | 4,288 | .8 | Gallatin silt loam, swampy phase | 15,872 | 3.1 |
| Manhattan very fine sandy loam, shallow phase | 7,488 | 1.5 | Minatare silt loam | 11,136 | 2.2 |
| Manhattan fine sandy loam | 7,680 | 1.5 | Minatare silt loam, brown phase | 640 | .1 |
| Manhattan fine sandy loam, smooth phase | 2,368 | .5 | Havre fine sandy loam | 12,160 | 2.4 |
| Manhattan fine sandy loam, gravelly subsoil phase | 1,216 | .2 | Havre fine sandy loam, dark-colored phase | 1,600 | .3 |
| Manhattan gravelly loam | 3,392 | .7 | River wash | 40,448 | 7.9 |
| Manhattan loamy sand | 1,984 | .4 | Rough broken and mountainous land | 129,984 | 25.3 |
| Millville silt loam | 5,248 | 1.0 | Total | 513,280 | ----- |
| Hyrum gravelly loam | 2,432 | .5 | | | |

## WELL-DRAINED FARMING SOILS

As stated, the group of well-drained farming soils includes soils having a rather wide range of color and texture in the surface layers and usually a number of common characteristics which may be the result of the soil-forming processes due to similarities of climate, character of the parent material, or some other factor. They are separated on the basis of texture, or the proportion of sand, silt, and clay in the surface soil. The characteristics of the lower part of the soil are also very important in determining the soil group to which a given soil type may belong. Within the soil types, there may be variations, and where these are sufficiently well defined and of importance, they are indicated as phases.

**Bridger loam.**—Bridger loam lies at the base of the Bridger, Gallatin, and Madison Ranges, on foothills and outwash fans, upon which the washing of material from the mountains by canyon streams has been most active. This soil occurs above the general elevation

of the valley, where the temperature is lower and evaporation is somewhat less than in other parts, and where the precipitation is higher than at any other place in the area. These conditions have been conducive to the growth of grasses and to the accumulation of organic matter, and a dark-brown or black soil has resulted.

The topsoil is dark grayish-brown or almost black loam which in most places contains some small fragments of gneiss. This dark-colored surface layer is in general from 9 to 12 inches thick, and it overlies grayish-brown noncalcareous gravelly loam. The subsoil ranges from light-brown to yellowish-brown loam which in most places is gravelly and difficult to penetrate with an auger. Because of the elevated position, pronounced slope, and the generally porous character of the surface soil and subsoil, drainage in most places is good, and where the land is irrigated, considerable loss from run-off and seepage frequently occurs. In the vicinity of Reese Creek, seepage from the mountains causes the lower slopes to be moist during the spring.

Small areas of soils which vary somewhat from typical Bridger loam have been included with it. South of Anceney and west of Gallatin Gateway considerable clay, resulting from the disintegration of shaly limestones, is mixed with material weathered from the gneissic rocks. The soil developed over these materials is much stickier than the average, and in some places it ranges in texture from heavy loam to clay loam. South and northeast of Cottonwood School, gneissic material is mixed with considerable silty wind-blown material, and over this has developed a soil approaching silt loam rather than loam. West of Anceney and southwest of Willow Creek a number of rather light colored bodies have been included with this soil. The soil in these areas contains a large quantity of recently disintegrated gneiss. It occurs in the drier part of the area where it could accumulate but little organic matter and is therefore light colored. A few areas of typical Bridger loam are intersected by areas of Bozeman silt loam or Amsterdam silt loam.

The surface relief of Bridger loam, although typically smooth and uniformly sloping, is in many places cut by ravines and canyon streams which have distributed masses of boulders near the canyon mouths.

Because of its rather favorable location with respect to rainfall, a fairly luxuriant vegetation grows on this soil. Wheat is probably the most important crop, and winter wheat has been grown more largely than spring wheat. Yields range from 15 to 40 bushels an acre, depending on the rainfall of the season. Alfalfa and timothy, in addition to the native grasses, are grown for hay with moderate success, and with irrigation the tonnage of these crops may be increased considerably. Alfalfa yields have not been so high as on many other soils in the valley, probably owing in part to the comparatively low lime content of this soil. In places the native mountain timothy has produced well.

**Bridger gravelly loam.**—Bridger gravelly loam occurs in conjunction with Bridger loam and merges into it imperceptibly. The general character of Bridger gravelly loam is similar to that of Bridger loam, except for the pronounced gravel content even at the surface. Because of its gravelly character, this soil is very leachy and is not so drought resistant as Bridger loam. Nearly all the loam member is

cultivated, but only about one-half of the gravelly loam is under cultivation, the rest being used for grazing. The content of nitrogen, phosphorus, and calcium is generally less than that of the loam soil. Small grains are the principal crop.

**Bridger stony loam.**—Bridger stony loam, by reason of its extreme stoniness, is not suited for growing cultivated crops. The larger areas of this soil lie at the base of the Bridger Range north of Reese Creek, where the canyon streams coming out of the mountains have strewn immense quantities of large boulders originating from different formations. Where water is available for irrigation, the grass cover may be stimulated considerably and thus provide excellent grazing. The rest of this soil has a very low agricultural value.

**Bridger silty clay loam.**—Bridger silty clay loam occurs on some of the mountain slopes in Bridger and Kelly Canyons, in the vicinity of Montellis Academy bordering Rocky Creek, and in the high hills west of Gallatin Gateway.

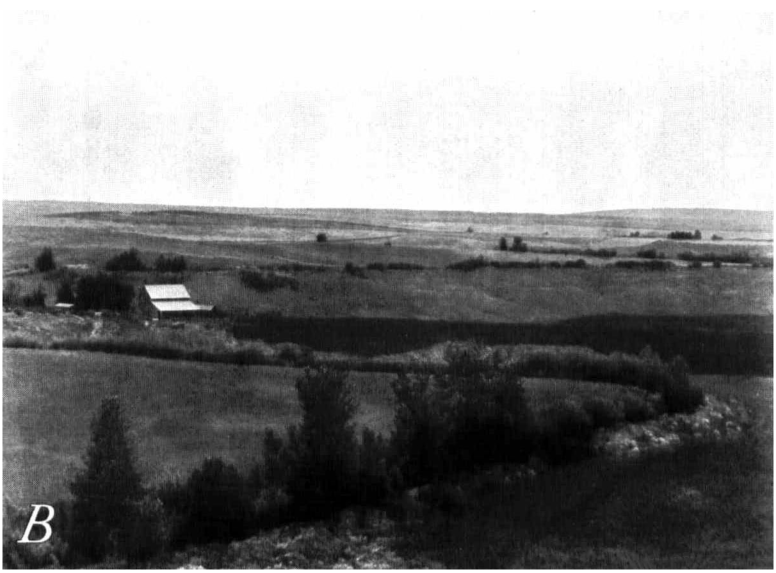
The 10- or 12-inch surface soil is dark grayish-brown or black silty clay loam or clay loam. It is underlain by compact sticky yellowish-brown silty clay which becomes somewhat friable and porous with depth. Scattered rock fragments may be present throughout the soil, and they are in general more numerous in the subsoil. Although somewhat heavy and refractory, under proper cultivation the soil becomes moderately friable and is well adapted to the growing of grain and timothy. In favorable situations, where some irrigation water may be supplied, alfalfa does fairly well.

**Bozeman silt loam.**—The surface layer of Bozeman silt loam is very dark grayish-brown somewhat laminated or fine-granular silt loam from 8 to 12 inches thick. The 5- or 6-inch subsurface layer is medium-brown fine silt loam or silty clay loam, that is rather compact, coarsely granular, and faintly prismatic. Below this material, the subsoil is yellowish-brown silty clay loam which in most places is rather friable and porous. In some places, however, as near the city limits of Bozeman, the material in this layer is brown, hard, compact, prismatic silty clay. Beginning at a depth ranging from 20 to 30 inches below the surface the lower subsoil layer is light-gray coarse silt loam which is very calcareous.

This soil occurs almost exclusively in the vicinity of Bozeman. It appears to be developed over the silty material of the "Bozeman lake beds." Conditions have been somewhat more favorable for the accumulation of organic matter here than in other parts of the valley, and a dark-colored soil has resulted. The surface relief of Bozeman silt loam is generally smooth and very favorable to cultivation. On the borders of areas of this soil, as south of Montana State College, some poorly drained land has resulted on account of springs coming to the surface at these points, but this is not a usual feature of the typical soil.

On the nonirrigated land, grain is grown almost exclusively, except on the Fort Ellis Experimental Farm about 3 miles east of Bozeman, where one cutting of alfalfa has been obtained without irrigation. Where irrigated, timothy produces a tonnage about equal to that of alfalfa. Some exceptionally high yields of grain also have been obtained.

The deep, fairly compact, silty character of this soil, together with its northern-slope exposure, does not facilitate warming up early in



*A*, Profile of Amsterdam silt loam, developed from wind-blown volcanic ash Uncontrolled waste water from irrigation caused the erosion *B*, Rolling area of Amsterdam silt loam in Godfrey Canyon west of Bozeman. Irrigation canal follows contours.



*A*, Gallatin and Minatare soils in East Gallatin River bottoms, north of Central Park. *B*, Irrigated rolling land of Amsterdam silt loam, with rough broken land adjoining.

the spring, hence bacterial action and, consequently, nitrification are somewhat retarded.

**Bozeman silt loam, brown phase.**—The brown phase of Bozeman silt loam is intermediate in development between the darker colored Bozeman silt loam and the lighter colored Amsterdam silt loam, all these soils being derived from essentially the same kind of material. The 8- or 10-inch topsoil of this phase of the Bozeman soil is deep-brown silt loam. The subsurface soil is light-brown or yellowish-brown friable coarsely granular silt loam, in most places somewhat prismatic. The upper part of the subsoil is light-brown very friable noncalcareous silt loam, and the lower part, below a depth of 20 or 24 inches, is gray highly calcareous friable porous very fine sandy loam. Below a depth of 3 feet, the material is uniform light grayish-brown very fine sandy loam.

The general surface relief ranges from gently sloping to rolling. The steeply rolling untillable areas are separated and are included with the miscellaneous classification of rough broken and mountainous land. Much of this soil lies at an elevation of more than 5,000 feet above sea level.

This soil is rather widely distributed in the southern and eastern parts of the Gallatin Valley, and it is an important agricultural soil. The principal areas are on Goochs Ridge between Middle Creek and Cottonwood Creek. Scattered areas lie south of Gallatin Gateway north of Bridger Creek on the slopes of the Bridger Range, and west of Bozeman bordering the Middle Creek bottoms.

The areas north of Bridger Creek paralleling the Bridger Range are for the most part nonirrigable and for this reason are largely used for the production of winter wheat. On the irrigable areas, grain crops are ordinarily alternated with forage crops. Alfalfa yields appear to be somewhat better at the lower elevations than in the higher areas bordering the mountains, owing in part, perhaps, to the fact that the soil warms up earlier at the lower elevations, thus promoting bacterial activity. Bordering the mountains at the higher elevations, the lime zone lies at a greater depth beneath the surface. The nitrogen content ranges from 0.092 to 0.138 percent, or from about 3,220 to 5,830 pounds per acre-foot.

**Amsterdam silt loam.**—In extent and general value for the production of farm crops, Amsterdam silt loam is one of the most important soils of this area. The surface soil is generally somewhat lighter colored and may have a more shallow humus-bearing layer than the brown phase of Bozeman silt loam. In several widely separated samples, the nitrogen content of the surface soil per acre-foot ranges from 0.076 percent, or 2,660 pounds, to 0.110 percent, or 3,850 pounds.

The topsoil, or organic layer, ranges from 5 to 8 inches in thickness. The subsurface soil to a depth of 14 inches is light yellowish-brown noncalcareous coarsely granular silt loam. The calcareous zone, between the usual depths of 14 and 30 inches below the surface, is very friable and porous very fine sandy loam. The lower subsoil layer, below depths of 25 or 30 inches, is also very calcareous but becomes somewhat browner with depth. In general, gravel is present only in the vicinity of bluff or terrace lines and on eroded surfaces of marked slopes. Where of sufficient extent, the gravelly areas are separated as a gravelly type of soil.

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The surface relief of Amsterdam silt loam ranges from undulating to rolling, and for the most part the land is not too rough or too steep for cultivation. Considerable care, however, is necessary in irrigating the more rolling land, because of the danger of erosion and the cutting of deep gullies (pl. 1, *A*).

The larger areas of this soil are south of Amsterdam and east of Camp Creek (pl. 1, *B*), extending to Gallatin River, and on the Bridger Range slopes east of Dry Creek. Small areas occur south of Reese Creek and on the high ridge south of the Scollard ranch. The principal irrigated area is west of Gallatin River. In this section, rather large quantities of alfalfa and peas are grown besides the various grain crops, of which wheat is the most important. Excellent yields of alfalfa are obtained when the land is properly handled. Although the organic-matter and nitrogen content of this soil are not high, these may be maintained by growing legumes and returning all manures to the land. In the dry-land sections, this soil normally produces high yields of wheat, and both winter and spring varieties are grown on summer-fallowed land.

**Amsterdam very fine sandy loam.**—The upper 3- or 4-inch layer of Amsterdam very fine sandy loam consists of very fine sandy loam containing, in places, a rather large percentage of silt. The color of the material is brown, and the structure is either laminated or loose and mulchlike. This layer is underlain by light-brown or grayish-brown very fine sandy loam which is either structureless or faintly prismatic. This material gradually changes, at a depth ranging from 9 to 14 inches, into light grayish-brown highly calcareous very fine sandy loam.

The greater part of this soil has a smooth gently rolling or nearly flat surface relief, and a large proportion of the land is under irrigation. In the irrigated areas in the vicinity of Amsterdam, some excellent yields of alfalfa and peas have been obtained. Although one irrigation for grain crops is sufficient in many places, several irrigations are necessary to obtain maximum yields of forage crops. The nitrogen content of this soil is low. It ranges from 0.07 percent, or 2,450 pounds, to 0.11 percent, or 3,850 pounds, per acre-foot, but it may be built up to some extent by a judicious system of crop rotation, which includes legumes, with the use of stable manure and the occasional plowing under of a green-manure crop of sweetclover or alfalfa. Some excellent irrigated pastures may be obtained.

**Manhattan very fine sandy loam.**—Areas of Manhattan very fine sandy loam have been mapped in the Dry Creek section, south of Manhattan and west of Camp Creek nearly to the Madison River breaks, and on the lower bench south of Three Forks and Willow Creek. This soil occupies a rather large territory and is somewhat variable, owing to a number of factors, such as water erosion, wind blowing, cropping, and general organic-matter content.

The soil south of Three Forks and west to the county line appears to be somewhat lighter colored than the areas east of the Madison River Valley. Many plowed fields, in which the material of the lime zone has been turned up to the surface, have an almost white appearance. Some of the more rolling and eroded areas east of Madison River also appear almost white in freshly plowed fields. Areas that have been subject to wind and water erosion are distinctly sandy in texture in the surface layer, whereas those located on the broader divide are

more nearly silty. In the eroded areas, lime may be present near the surface, but in the normal undisturbed soil the lime zone ranges from 6 to 10 inches beneath the surface.

Much of the land included with this soil is gently rolling. The area south of Three Forks is in general smooth. A large part of the land, however, is somewhat cut by coulees, most of which have at least some steep or broken untillable land bordering them. Where of sufficient extent these rough broken areas are separated from the typical soil and included in a miscellaneous classification.

A rather large proportion of this soil is so situated that it cannot be irrigated, at least at the present time. The agriculture, therefore, is limited to wheat growing and grazing. Practically all the tillable land has at some time been plowed, so that virtually all the native sod has been destroyed. Although some excellent wheat yields have been obtained during years of favorable moisture supply under summer fallow, it is doubtful that the plowing of much of this land has been justified. Since the native sod has been destroyed, soil blowing has increased and water erosion, particularly during storms of the cloudburst type, has been facilitated. This has resulted in decreased yields of spring wheat. Much of this land has been abandoned and is now supporting only a cover of weeds.

**Manhattan very fine sandy loam, colluvial phase.**—The colluvial phase of Manhattan very fine sandy loam occurs in several isolated bodies, the largest of which is south of Manhattan in the vicinity of Buell. Areas of this soil on colluvial slopes bordering the uplands are in the Madison River Valley and bordering Gallatin River near Holland.

The soil material is similar to that of typical Amsterdam very fine sandy loam or Amsterdam silt loam. It differs in texture from place to place, according to the texture of the parent material, but the greater part is very fine sandy loam. It also varies somewhat in color from brown to dark brown, depending somewhat on the accumulation of organic matter. In many places the surface soil is slightly calcareous or somewhat streaked with calcium carbonate. At a depth of 7 or 8 inches beneath the surface, the light grayish-brown very fine sandy loam is in general strongly calcareous, although the lime is well distributed. The lower part of the subsoil is very similar to the corresponding layer of the associated soils.

This colluvial soil commonly occurs on the foot slopes of the adjoining uplands, and in such positions it receives seepage water from the higher lands. In areas of restricted drainage, some alkali accumulation may result, as has been the case just south of Manhattan. Otherwise this soil when irrigated is generally superior in crop production to the associated soil types.

**Manhattan very fine sandy loam, shallow phase.**—The character and color of the surface soil of Manhattan very fine sandy loam, shallow phase, in most places is similar to the characteristics of Amsterdam silt loam, although it is in general shallower. This soil occurs on the slopes of Horseshoe Hills and north of Menard.

The 2-inch surface mulch is brown laminated granular silt loam which overlies a layer of brown laminated or platy silt loam ranging from 5 to 8 inches in thickness. The subsurface soil is very light gray distinctly calcareous silt. Below the calcareous zone, a thinly bedded calcareous sandstone is present in many places at a depth

ranging from 12 to 24 or more inches. Madison limestone fragments are scattered over the surface and through the soil, though these are not numerous in most places. This soil is apparently of mixed derivation, being in part residual and in part derived from wind-blown materials similar to the parent material of the Amsterdam and Bozeman soils.

In the past, the tillable areas of this soil have been used for the production of wheat, but much of the area is now lying idle and weeds make up the principal vegetal cover. In years of favorable distribution of rainfall, fair yields of wheat are obtained, but, largely on account of unfavorable precipitation, only low yields can be expected.

**Manhattan fine sandy loam.**—Manhattan fine sandy loam is much less drought resistant than the very fine sandy loams or silt loams of this group, because of its coarse texture. The surface soil is light grayish-brown coarse loamy sand or fine sandy loam to a depth of 7 or 8 inches. This layer is underlain by calcareous light-gray fine sand which passes below into the coarse disintegrated lake-bed deposits.

This soil occurs principally south of Logan on the high ridges and slopes bordering the Madison River Valley breaks. It also occupies some colluvial slopes below the breaks in the Madison Valley. Isolated bodies occur in the western part of the area.

The soil has a low water-holding capacity, because of its coarse texture, and in this area, where rainfall is uncertain, the only practical utilization of this land is for grazing. The native grasses consist largely of needlegrasses and red bunch grasses.

**Manhattan fine sandy loam, smooth phase.**—The smooth phase of Manhattan fine sandy loam occurs in a single area in the vicinity of the town of Manhattan. It occupies what appears to be a large outwash plain or bench that has been formed during the degradation of the hills to the south and west.

The surface soil is light-brown or brown fine sandy loam which continues without much change in color or texture to a depth ranging from 15 to 18 inches. Below this depth, the subsoil is gray highly calcareous very fine sandy loam. At a depth ranging from 24 to 36 inches, layers of fine sand and gravel are present.

Because of the texture and open, porous character of this soil, it is well drained and requires generous applications of water for the production of crops. The soil is naturally deficient in organic matter and nitrogen, but it may be improved by growing leguminous crops and by the use of green and stable manures. This soil is not generally adapted to dry-farming methods, but with a rather copious supply of irrigation water it is fairly well adapted to the growing of alfalfa and other forage crops, grains, and vegetables.

**Manhattan fine sandy loam, gravelly subsoil phase.**—The gravelly subsoil phase of Manhattan fine sandy loam borders the uplands south and west of Manhattan, particularly at the mouths of coulees coming out of the hills. Varying quantities of gravel are scattered throughout the soil, more particularly the subsoil. Soil of this phase is very similar to the typical soil, but it is variable as regards texture and gravel content. The soil has received wash from the uplands which consist of very fine sandy loams or silt loams, so that the general texture averages somewhat nearer a loam and contains a larger quan-

tity of lime. This soil is farmed much the same as typical Manhattan fine sandy loam, and crop yields average somewhat better.

**Manhattan gravelly loam.**—Manhattan gravelly loam represents several areas of the soils of the Manhattan series, which have rounded gravel scattered over the surface. Such areas are located, for the most part, below escarpments or bordering coulees, and they exist as outwash fans or eroded surfaces. The soil material is similar to that of Manhattan very fine sandy loam. The existence of the gravel, however, makes this land somewhat less desirable than the gravel-free areas. Soils of several textures are grouped under this designation, but the dominant soil is gravelly loam. The nontillable and rough broken areas of gravelly land are included in the miscellaneous soil classification designated as rough broken and mountainous land.

**Manhattan loamy sand.**—Manhattan loamy sand occupies the northern border of the Manhattan bench where the surface soil consists of light grayish-brown loamy fine sand which becomes very calcareous fine sand at a depth ranging from 12 to 15 inches. Gravel is scattered over the surface near the breaks of the bench or bordering coulees. Gravel and sand strata occur at a depth ranging from 12 to 24 inches. The greatest depths at which gravel occurs, are farthest away from the coulees and the border of the bench. This soil requires even larger quantities of irrigation water than Manhattan fine sandy loam because of its coarse sandy character. The organic-matter content also is naturally very low.

**Millville silt loam.**—Millville silt loam occurs in the vicinity of Springhill and north of Wisner. It appears to have been developed over outwash material from the Bridger Range. The 7- or 8-inch surface layer is brown or dark-brown laminated or finely granular silt loam. The subsurface layer to a depth of 20 inches is friable brown silt loam of blocky or irregular structure. The subsoil is brown silt loam irregularly streaked with lime. With the exception of these streaks, the soil is only mildly calcareous. Well-rounded gravel is scattered throughout the subsoil. The lower part of the subsoil consists of light grayish-brown gravel and fine sand.

This soil is used mainly for the production of wheat, and in the past some excellent yields have been obtained. Generally speaking, however, average yields are now somewhat less than in former years, owing to the almost continuous cropping to this grain. Nitrogen is in general somewhat deficient; hence practical means of increasing the organic-matter content will be an important factor in maintaining yields. Small bodies of this land are irrigated during early summer from Bostwick Canyon (outside the area) and Ross Creek. Where water is available, small tracts are devoted to alfalfa.

**Hyrum gravelly loam.**—Hyrum gravelly loam occurs in association with Millville silt loam. In color and general character, these two soils are very similar, except that in the Hyrum soil gravel in rather large quantities is scattered over the surface and throughout the subsoil, and in places it interferes considerably with cultivation. Because of its gravelly character, this soil is very porous and does not have a high moisture-holding capacity. In cultivated areas, the humus material is quickly destroyed. For the most part this land is dry farmed, and in favorable seasons fair yields of wheat are obtained. The irrigated areas require a rather large quantity of water, in order to produce satisfactory yields of such crops as alfalfa.

**Ashuelot gravelly loam.**—The organic surface layer of Ashuelot gravelly loam is brown laminated silt loam from 5 to 8 inches thick. Rounded gravel and, here and there, lime-cemented gravel are scattered over the surface and throughout the soil. The subsurface layer is light grayish-brown gravelly very fine sandy loam which in most places is streaked with calcium carbonate at a depth ranging from 15 to 18 inches. The subsoil, below a depth of 18 or 20 inches, is semicemented very light gray fine sand and gravel. Large hardened fragments or blocks originating in this layer are brought to the surface wherever the covering is shallow enough for the plow or other tillage implements to reach it. This occurs principally at the breaks of the benches where considerable erosion has taken place. Deep coulees have cut back into the bench for rather long distances, giving rise to some very rough and broken land bordering the bench on the north and east.

This soil is mapped principally on the high bench and ridges in Tps. 1 and 2 S., R. 1 E., and on the eastern border of the lower bench in T. 1 N., Rs. 1 and 2 E. Smaller and isolated bodies occur on the lower benches toward Three Forks. These bodies differ in size and in the quantities of gravel and rock that occur over the surface. The texture of the surface soil ranges from clay loam to heavy loam or silt loam. In a few places some lime-cemented gravel blocks or fragments occur on the surface, having been plowed up or brought to the surface by cultivation.

On the lower bench bordering the Madison River Valley in T. 1 N., R. 2 E., the surface soils are somewhat lighter colored, are shallow, and lime-cemented gravel is more in evidence at the surface. This is perhaps caused in part by the fact that this area has been more extensively cultivated. It has been used largely for the production of spring wheat. During the last 2 or 3 seasons, the drought has been so severe that the lower benches have been abandoned to a great extent, but the higher benches to the south have continued to return fair yields of winter wheat.

Soil blowing is a problem that must be contended with, if this section is to continue in wheat production. The organic-matter or humus content of these soils in their native state is low. Cultivation soon disseminates the original organic material, and the soil becomes subject to severe blowing, particularly during dry seasons.

**Beaverton gravelly loam.**—Beaverton gravelly loam occurs largely in an area surrounding the town of Belgrade. In comparison with Beaverton loam, it has a much shallower organic surface layer, a high percentage of rounded gravel scattered over the surface, and distinct gravel strata at a depth ranging from 6 to 15 inches below the surface. From the point of view of crop production, this soil is much inferior to Beaverton loam, with which it is associated. In areas that approach the character of the loam, fair yields of alfalfa are obtained when sufficient irrigation water is applied. Because of the gravelly and rocky character of the soil, it is difficult to level the land for efficient irrigation, and under the best conditions large quantities of water are necessary to obtain even meager yields.

**Beaverton loam.**—Beaverton loam is somewhat variable as to color, texture, and quantity of gravel occurring in the surface soil and subsoil. The surface, or organic, layer may range from 6 to 10 inches in thickness, and it ranges from medium brown to rich brown in color.

Small quantities of gravel are scattered through the soil. The texture ranges from light to heavy loam, the loam areas containing a somewhat higher percentage of clay material. The subsurface layer is rich-brown or yellowish-brown silty clay loam which is coarsely granular and in most places is somewhat prismatic and noncalcareous.

The lime zone occurs at a depth ranging from 15 to 20 inches beneath the surface. It consists of light-gray strongly calcareous silty loam. Distinct gravel beds are reached at variable depths, in most places below depths of 2 feet.

This soil is associated with Beaverton gravelly loam, and in many places it merges into large bodies of very gravelly land. Beaverton loam extends from the upper courses of Middle Creek and Gallatin River to the valley trough north of Belgrade. The soil occurs as nearly level areas, except in the vicinity of old stream channels which may be marked by parallel ridges and depressions. Much of the land is irrigable from the present canal construction.

The water-holding capacity and the productive value of this land depend to a large extent on the depth of the soil material overlying the gravel beds and also on the quantity of loose gravel scattered through the soil. In some places the soil may be so porous that very large quantities of irrigation water would be necessary for crop production, particularly on the more gravelly areas. On the better areas, good yields of alfalfa, peas, and wheat are obtained. A rather consistent plan of rotation, including the use of manures, should be followed in an endeavor to maintain the nitrogen content of the soil.

**Beaverton loam, dark-colored phase.**—The dark-colored phase of Beaverton loam occurs principally in the southern part of the area, bordering Cottonwood Creek, and along Gallatin River south of Gallatin Gateway. This soil has a dark grayish-brown loamy surface soil containing some gravel, and in most places it is 9 or 10 inches thick. It overlies a layer of medium-brown harsh compact coarsely granular heavy silty loam. Below a depth of 17 inches, the subsoil becomes gravelly, and the lower subsoil layer, below a depth of 24 inches, consists of calcareous sand and gravel. Practically the same crops are grown as on the typical soil, except that alfalfa is replaced by timothy to some extent.

### IMPERFECTLY DRAINED FARMING SOILS

The group of imperfectly drained soils includes the lower lying alluvial soils of the area. They vary in moisture content from only slightly affected soils to those in an almost saturated condition approaching swamps. These soils also vary in alkali content, depending on the quantity of salts in the soil and on drainage conditions, which determine whether the salt-laden waters are carried away or evaporate on the land, leaving their salt.

**Huffine silt loam.**—The Huffine soils, of which the silt loam is of the greatest extent and value, extend in an area, ranging from 4 to 5 miles in width, west of Bozeman and south nearly to the Gallatin Range. These soils are somewhat variable as to their content of gravel in the surface soil, depth to the gravel subsoil or substratum, and also as to the degree of drainage and depth to ground water at different seasons of the year.

On the eastern border of the experiment station plats, the 9- or 10-inch surface layer is dark-brown silt loam which grades below into

compact silty clay loam. Spots of the heavy silty clay loam appear at the surface in places, owing to leveling and washing of the surface soil by irrigation water, and they are distinctly noticeable, both in handling the soil and in crop growth. Below a depth of 15 or 16 inches, the subsoil becomes slightly calcareous yellowish-brown silty clay loam. Below a depth of about 20 inches, the calcareous material gives the subsoil a light grayish-brown color. Gravel layers over the entire area may range from 2 to 4 feet below the general land surface. Where the gravel layers are nearer to the surface, there is a corresponding shallowness in the overlying soil layers.

The surface relief of Huffine silt loam is, in general, fairly smooth, and the land slopes toward the north. Many shallow sloughs or drainageways, having a general northerly direction, traverse the area. These drainageways carry much water during the spring and summer, especially duiing the irrigation season. It has been noted that the ground-water level is highest early in June, during heavy irrigation of fields to the south.[3] A number of roadside ditches have been constructed, so that much of the ground water is picked up and directed to the larger stream channels. Although surface drainage of this area is generally fairly good, except in the lower sloughs, the water table fluctuates, depending on the amount of irrigation necessary, and in places it limits the growth of alfalfa. In the better drained areas and deeper soils, yields ranging from 4 to 5 tons are obtained. Yields of spring wheat under irrigation on this soil may range from 45 to 60 bushels an acre, depending somewhat on soil preparation and the extent of weed infestation. Good yields of oats and barley are also obtained under similar conditions. Acre yields on the experimental plats have averaged around 120 bushels of oats and 80 bushels of barley.

**Huffine silt loam, poorly drained phase.**—The poorly drained phase of Huffine silt loam includes all the shallow sloughs, depressions, or drainageways, through which much of the waste water from seepage and overirrigation passes, also the broad low flats where the ground water collects during the irrigation season.

The soil material of this phase is much the same as that of the typical soil, but there are greater variations. The surface soil in most places is darker, and in many places it is shallower and more gravelly. The gravel layer lies relatively nearer the surface. In some areas, as northeast of Rea School, silty material has collected, and the dark organic soil is deeper than normal, and in places a sticky clay has been deposited over the gravel. This clay becomes rather impervious and allows but little percolation, therefore the only means of escape of the excess water is through openings that may be provided. It is fortunate that these soils in general do not contain excessive quantities of troublesome alkali salts.

This soil for the most part is utilized only for grazing. Where the land does not become boggy and the water table does not come within a few feet of the surface, some excellent pastures may be maintained. Bluegrass, timothy, redtop, and the wheat grasses grow here, depending somewhat on the degree of drainage afforded.

**Huffine gravelly loam.**—Several small areas of Huffine gravelly loam occur in this area, mainly southwest of Bozeman. The surface soil to a depth of about 8 inches is dark grayish-brown loam containing

[3] MURDOCK, H. E. SEEPAGE AND DRAINAGE OF IRRIGATED LAND. Mont. Agr. Expt. Sta. Bull. 255, 32 pp., illus. 1932.

a small percentage of small gravel. Below this the color changes gradually, and at a depth ranging from 15 to 18 inches it becomes grayish brown. The material gradually becomes sandier and the percentage of gravel increases with depth. At a depth ranging from 20 to 24 inches there is a mass of gravel embedded in nearly white calcareous fine sandy loam or silt loam. Over a large part of this soil, the profile does not differ from that of Huffine silt loam except in the larger percentage of gravel in the surface soil and subsoil.

This soil occurs in low areas along streams or at the heads of streams. Drainage is deficient, and in places the land is water-logged a large part of the year.

The agricultural value of this land is slightly lower than that of Huffine silt loam.

**Gallatin silty clay loam.**—Gallatin silty clay loam occurs over a heavy alluvial deposit of variable drainage in scattered areas bordering Gallatin River and East Gallatin River and in the central part of the valley northwest of Bozeman. West of Gallatin Gateway this soil is noncalcareous very dark brown clay loam underlain by mottled gray and brown loam. At a depth of about 20 inches, the subsoil is dark-gray fine silt or silty clay loam noticeably streaked with lime. The lower part of the subsoil, below a depth of 36 inches, is light-gray fine sand.

In the central part of the valley bordering Middle Creek, this soil is dark grayish-brown fine granular or cloddy compact silty clay in the surface layer. The subsurface layer, which occurs between depths of 6 and 12 inches, is olive-gray hard granular silty clay. This layer, in turn, is underlain by gray calcareous silt loam. The material in the lower part of the subsoil is fine sand and gravel.

Areas of this soil are for the most part fairly well drained, although in many places they border poorly drained areas having a high water table. Where fairly well drained, the land is productive, although it is somewhat difficult to handle. Alfalfa, grain, and timothy and other grasses are grown.

**Gallatin silt loam.**—Gallatin silt loam is rather extensively developed along East Gallatin River, extending from Bozeman to north of Central Park (pl. 2, *A*). The areas on the upper reaches of the stream valley are somewhat better drained than the more northerly areas. The body of this soil in the vicinity of Lux is fairly well drained.

The surface soil is dark-brown or black silt loam which becomes silty clay in the subsurface layer but is rather friable and noncalcareous. The subsoil, below a depth of 20 inches, is light-brown or gray calcareous silt loam.

North of Belgrade, this soil in most places is moist and poorly drained in the subsoil. Here the surface soil is dark brown, loose, and slightly calcareous. The subsurface soil, from 10 to 23 inches, is grayish-brown silt loam. The subsoil is light-gray perennially moist very calcareous silt loam.

The utilization of this type of land depends to a large degree on local drainage conditions. The better drained areas are fairly productive, and grain and hay are the principal crops. However, much of this land is used for pasture.

A loam phase of Gallatin silt loam occurs in three main areas, bordering Reese, Rocky, and Bozeman Creeks. This included soil has a somewhat higher content of organic matter than the other

soils of the Gallatin series. The surface soil is dark-brown or black loam ranging from 12 to 15 inches in thickness. The subsoil in many places is mottled gray and brown loam, in some places streaked with iron and lime. Gravel and fine sand are reached in most areas at a depth of 3 feet or deeper. In areas bordering Rocky Creek, the texture of the surface soil is in places loam which contains a somewhat higher percentage of clay.

This soil is very productive where fairly well drained. The area south of Bozeman along Bozeman Creek is utilized largely in growing truck crops, such as cabbage, tomatoes, carrots, and cucumbers, to supply the local market. Other areas are used for grain and pasture.

**Gallatin silt loam, swampy phase.**—The swampy phase of Gallatin silt loam occurs wherever the land is in a more or less permanently swampy condition because of seepage or a high water table. This soil consists of dark-colored silt loam underlain by gray or light-brown silt loam. This swampy land will be used only for grazing purposes, at least until some of it has been drained. Most of the swampy areas are not seiiously affected by alkali.

**Minatare silt loam.**—Minatare silt loam is distinguished from the Gallatin soils by its light-colored surface soil as contrasted to the dark color of the latter. These soils are poorly drained and are affected by considerable alkali, as evidenced by the salt accumulations and the character of the vegetation, such as the saltgrasses.

North of Central Park the surface soil is light grayish-brown silt loam which is streaked with lime and other white salts. Below a depth of 10 inches the soil is very light gray structureless silt loam which continues to a depth of more than 5 feet.

In the Madison River Valley the light-brown surface soils are underlain in many places by yellowish-gray silty clay streaked with calcium carbonate and other salts. Much of this area, however, is underlain by gravel strata at variable depths. Loose gravel may also be scattered through the surface soils. The entire Madison Valley area is subject to a high ground-water table and, except for small tracts, is used only for grazing.

**Minatare silt loam, brown phase.**—The brown phase of Minatare silt loam occurs in a small tract north of Central Park adjoining the main area of the typical soil. Because of better drainage and a lower ground-water level, less alkali salts have accumulated, and cultivated crops, including alfalfa, may be grown.

**Havre fine sandy loam.**—Havre fine sandy loam is a soil of recent alluvial origin, scattered in various better drained areas in the valley bottoms. The texture of the surface soil, to a depth of 12 inches, ranges from loam to very fine sandy loam and the color from brown to dark grayish brown. The subsoil is gray or dark-gray fine sandy loam. Bordering the larger streams, such as Gallatin, Madison, and Jefferson Rivers, gravel may be mixed with the surface soil, and they invariably occur at some place in the subsoil at a depth ranging from 1 to 3 feet.

This soil is, in general, mildly calcareous but has no concentrated lime layer such as occurs in the bench lands. In many places the land is subject to overflow during times of unusually high water. It is adapted to the production of vegetables, as well as grain and hay crops.

**Havre fine sandy loam, dark-colored phase.**—A few small areas of a dark-colored phase of Havre fine sandy loam occur in Jefferson River Valley and along Willow Creek. In the Willow Creek bottoms, the surface soil is noncalcareous dark grayish-brown fine sandy loam to a depth of 12 inches, below which the subsoil is dark-gray silty clay loam. Other areas, however, are distinctly sandy throughout the profile.

### NONAGRICULTURAL LAND

The nonagricultural land is included in two miscellaneous groups designated as river wash and rough broken and mountainous land.

**River wash.**—River wash borders the major stream courses, particularly Gallatin, Madison, and Jefferson Rivers. It occupies large areas of sand and gravel bars that are in part covered with brush, willows, and cottonwoods. These areas are for the most part unsuited to cultivation and are subject to change with every overflow. Some of them support a sparse cover of grasses and weeds, that may be used for grazing. The largest areas of sand and gravel deposits occur near the mouth of Madison and Jefferson Rivers in the vicinity of Three Forks. Bordering the Madison Valley breaks, a number of coulees have deposited masses of rock and sand in fans at their mouths. These areas also are unsuited for cultivation.

**Rough broken and mountainous land.**—Rough broken and mountainous land includes all land untillable because of steepness or stoniness. Large areas of rough broken land occur along the borders of the Madison River Valley and are spoken of as "breaks." In some areas, as west of Hot Springs, west of Anceney, and south of Willow Creek, there are many gneiss and limestone outcrops that virtually preclude cultivation. Bordering most of the large coulees, particularly in the western part of the area, are large tracts of rough broken land, many of which have considerable gravel scattered over the surface and through the soil. This land includes many types of soil materials. The grass cover is variable, depending on the steepness of the slope and the extent of erosion that has taken place. In general, however, the rough land in the eastern and southern parts of the area has a better grass cover, and therefore its value for grazing is somewhat greater. Mountainous land occurs in the Gallatin Valley area mainly on the southern and eastern boundaries. It is for the most part steep and rocky timbered land.

## AGRICULTURAL METHODS AND MANAGEMENT

The agriculture of the Gallatin Valley area may be roughly divided into two types—irrigation farming and dry-land farming. The part of the area that may be irrigated is limited by the surface relief and elevation and by the available water supply. The greater part of the irrigated land parallels the course of Gallatin River, from which a large part of the necessary water is obtained. Small irrigable areas occur in the Madison River, Jefferson River, and Willow Creek Valleys.

Although the Gallatin Valley area cannot be considered a district of diversified agriculture, the availability of water for irrigation is a distinct asset in growing a number of crops, particularly legumes, and it also insures greater dependability in the production of grain crops.

Several factors, such as elevation, latitude, length of growing season, and distance from consuming centers, limit the adaptability of the area to a small number of crops. With the production of livestock, the growing of hay crops and feed crops has become an important part of the farming program. It is natural therefore that the agriculture should be built primarily around the production of livestock.

Alfalfa is a very important forage crop in this area, particularly on all the better drained soils. Probably the most favorable soils for the production of alfalfa are the brown phase of Bozeman silt loam and the Amsterdam soils. These soils have a favorable, porous structure, a high water-holding capacity, are not subject to fluctuations of a ground-water table, and are fairly well supplied with phosphorus and lime. The less favorable soils for the production of this crop are the higher lying Bridger soils which are slow in warming up in the spring and also are comparatively low in lime. The higher mountain slope soils are probably better adapted to the production of timothy and red clover than of alfalfa. Low yields are obtained on the very gravelly soils of the Beaverton and Huffine series.

For the most part, maintenance of the nitrogen content of the soils of the Gallatin Valley must be accomplished through the use of manure, wherever available, the growing of legumes, such as alfalfa or sweetclover, and the occasional turning under of these crops as green manure. This procedure is particularly applicable on the lighter colored soils. In the irrigated-crop rotation experiments at the Montana Agricultural Experiment Station at Bozeman, located on Huffine silt loam, the nitrogen level generally has been higher in the rotations which have included the liberal use of manure or the growing of alfalfa for 3 years. The effect of the alfalfa crop on the following grain crops also is marked. The highest yields of spring wheat on the experiment station plats of the various rotations were obtained following 3 years of alfalfa. The protein content and general quality of the grain also have been comparatively high, owing to the amount of nitrate nitrogen available.

Oats and barley are important feed crops that may be grown instead of wheat on almost any soil in the area when there is a demand for these crops. Soft white wheats are frequently grown for feeding purposes.[4] Because of the ease with which hay and grain crops may be produced under irrigation, many of the larger livestock operators locate the home ranch in the valley, where it is possible to obtain irrigation water, and lease large areas of dry land for grazing purposes, or regularly make use of the national forests during the summer-grazing season.

Weed infestation has become a very serious matter on many of the more important soils, particularly those largely under irrigation. The distribution of weed seeds is greatly facilitated by irrigation water. This emphasizes the importance of controlling weeds along canal banks and in the fields, and particularly of not allowing the seed to mature. Canada thistle is one of the most dangerous weeds, because of its deep-rooting habits and the consequent difficulty of its control.

[4] Detailed recommendations regarding crop varieties may be obtained from the agronomy department of the Montana Agricultural Experiment Station at Bozeman.

In the nonirrigated or dry-land areas, wheat production has been and will continue to be of importance in sections which are favored so far as natural precipitation is concerned. At the higher elevations, as bordering the Bridger and Gallatin Ranges and the Madison foothills, winter wheat has been grown to considerable extent. Because of increasing trouble from winter-killing and losses from stinking smut, more spring wheat has been grown in late years.

Tillage practices, particularly the thoroughness and frequency of good summer-fallow practices, depend to a rather large degree on the location of the particular soil. On the dark soils bordering the Bridger and Gallatin Ranges, where the rainfall is somewhat greater than elsewhere, summer-fallowing is not practiced so frequently as on soils in the western and northern parts of the area. During the last few years, when the supply of moisture has been low, the methods ordinarily considered as best adapted have not served to forestall crop failure in certain sections.

## IRRIGATION [5]

Irrigation in the Gallatin Valley dates back to 1864 when the first settlers arrived. Two main streams, Gallatin and East Gallatin Rivers, with their tributaries, furnish the water supply for irrigation. The natural summer flow of both streams is completely utilized for irrigation, and during dry years some of the later rights are shut off early in the season. Further expansion of the irrigated area is possible by building reservoirs in which to store the spring run-off, or high water. The decreed water rights in Gallatin River allow from 0.75 to 1 miner's inch an acre, which amounts to a 2-second-foot head for each 80 acres, or 4 cubic feet a second for each 160 acres. The amount of water delivered to each farm is usually much less than this, owing to losses from seepage in the main canals.

The principal crops grown under irrigation are hay, including alfalfa, timothy, red clover, and sweetclover; grain, including wheat, oats, and barley; peas, for seed and canning; potatoes; truck crops; and pasture.

Irrigation practices and the methods in use have changed but little since the early settlers first came to the valley. The prevalent method is a modified form of wild flooding, which differs from contour flooding in that the field laterals or irrigating ditches are made in the direction of steepest slope or diagonally downward across the slope, without regard to a particular grade, and in that they are spaced closer together than is necessary where the contour-flooding method is used. The tendency to disregard the lay of the land in applying irrigation and in handling waste water is resulting in the loss of immense quantities of rich surface soil and the formation of large washes or gullies. This is particularly true of the rolling phases of certain soil types, such as Amsterdam silt loam (pl. 2, *B*). In contour flooding the ditches are run on a gentle uniform grade, such as will cause only a moderate velocity of flow and not erode the soil. Where the ditches are run parallel to the steepest slope, they must be spaced close enough that the water will spread over at least one-half

[5] This section of the report was prepared by O. W. Monson of the agricultural engineering department, Montana Agricultural Experiment Station.

of the distance between ditches. Where contour ditches are used, the spacing is limited by the distance the water will flow down the slope without excessive soaking at the upper end.

The size of stream ordinarily handled by one man, using the flooding method, varies from 0.75 to 1.5 cubic feet a second, or from 30 to 60 miner's inches. From 3 to 4 acres a day are irrigated. This amounts to an average application ranging from 6 to 9 inches in depth at each irrigation. Where heavy irrigations are applied, the average amount for the season may equal a depth of 33 inches, or 11 inches for each irrigation. With the comparatively shallow soils these heavy irrigations result in large losses through percolation. The rise in the water table around Belgrade and Central Park is an indication that an excessive amount of water is applied in many places in the upper part of the valley. In a study of the irrigation and drainage problems of the Gallatin Valley, it was learned that the water table begins rising soon after irrigation commences each season, and as the season progresses the peak in the high water table moves down toward the lower end of the valley, reaching the swamps in October and November.

Better preparation of the land and more careful location of ditches, together with improved methods of irrigation will make possible a more economical use of water in this valley.

According to the census data for the years 1889 and 1899, there were 434 and 659 farmers, respectively, who irrigated their lands in those years, and the acreage irrigated was recorded as 46,901 and 60,267 acres for the respective years. The Fourteenth Census classified the acreage irrigated by drainage basins. The acreage irrigated in the Gallatin River basin and the Madison River basin in 1919 is recorded as 95,063 acres and 34,425 acres, respectively. The Gallatin River basin figures relate wholly to Gallatin County, and those for the Madison basin relate partly to Madison County. Table 7 shows the status of irrigation enterprises in Gallatin County in 1909, 1919, and 1929.

TABLE 7.—*Status of irrigation enterprises in Gallatin County, Mont., in stated years*

| Year | Area irrigated | Increase or decrease in 10-year period [1] | Area enterprises were capable of irrigating | Increase or decrease in 10-year period [1] | Irrigable area in enterprises | Increase or decrease in 10-year period [1] |
|---|---|---|---|---|---|---|
| | *Acres* | *Percent* | *Acres* | *Percent* | *Acres* | *Percent* |
| 1909 | 127,449 | | 139,050 | | 169,926 | |
| 1919 | 103,975 | −18.4 | 174,906 | 25.8 | 287,590 | 69.2 |
| 1929 | 112,792 | 8.5 | 136,621 | −21.9 | 147,838 | −48.2 |

[1] Decrease denoted by minus sign.

Although there has been an increase in the amount of land actually irrigated, there appears to have been an abandonment of some land that was formerly considered a part of the various irrigation enterprises. In figure 3 is shown the location of the irrigated lands in the Gallatin Valley area.

## SOILS AND THEIR INTERPRETATION

The Gallatin Valley area occupies one of the higher valleys of the intermountain sections of northwestern United States. The climate is continental in character and is subject to wide extremes of seasonal and daily temperatures. The mean annual precipitation ranges from about 10 to 18 inches in different parts of the area. Moisture and temperature have an important effect on the character of the soils, as they directly influence the native vegetation and the process of leaching, oxidation, aeration, and accumulation of organic matter. The soil variations brought about by differences in native vegetation and climatic conditions are clearly evident in crossing the area from

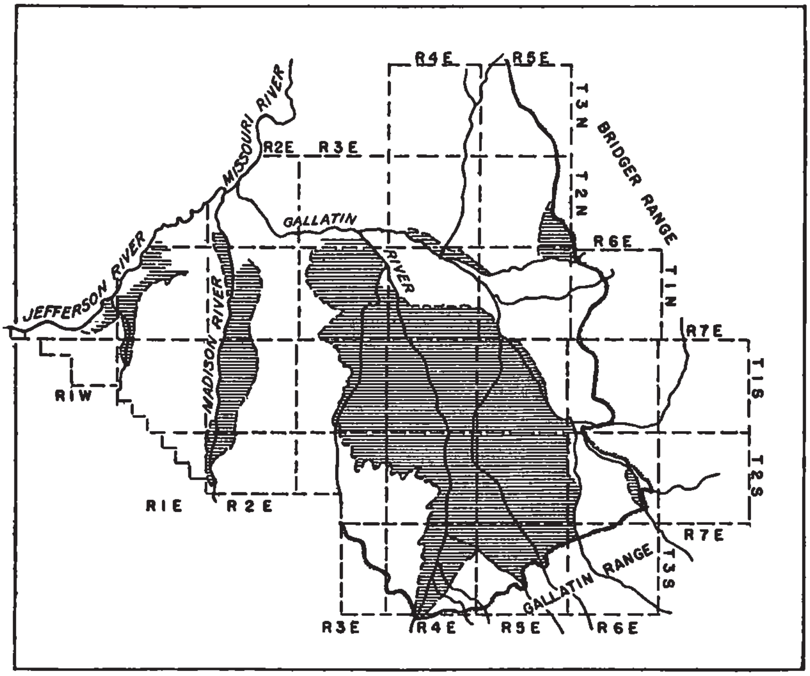


FIGURE 3.—Sketch map of the Gallatin Valley area, Mont., showing location of irrigated lands.

the sections having higher rainfall in the eastern part to the more arid western part.

The normally developed soils vary in color according to the relative quantities of organic matter which have accumulated. The precipitation and temperature of the higher slopes bordering the mountain ranges on the east and south have favored a luxuriant growth of grasses and a consequent accumulation of organic matter. The soils in this section show the influence of the grass cover in the dark color of their topsoils. Westward and northward from the mountain ranges, the precipitation decreases and the temperature increases slightly. As a result, much less organic matter has accumulated.

In relation to the great soil belts of the world, the soils of this area, which lie in elevated regions of higher moisture supply, belong

to the Chestnut-Brown soils group. From the area of darker colored soils a rapid transition takes place to the lower plains and valleys, and here the soils are distinctly of the Brown-soils group.

By far the greater proportion of the normal soils of this area are brown or light brown. With few exceptions, all the soils have friable or only moderately compact suboils, most of which include a zone of lime accumulation. The precipitation has not been sufficient to leach the calcium carbonate from the entire soil but has removed it from the surface layers to the subsoil or substratum, causing an unusually large accumulation of this material at some place in the soil profile, except in areas where drainage may be excessive or very poor or where erosion has been severe.

Both topsoils and subsoils have developed layers, or horizons, differing from one another in one or more important features, such as color, lime content, texture, structure, and compaction. The characteristics mentioned are not everywhere equally expressed. They are the result of the climate and vegetation under which the soils have developed, and they are strongly expressed only in those soils which have received the full impress of their climatic and vegetative environment. Such soils occupy well-drained uneroded parts of the area, where conditions have been most favorable for prolonged undisturbed development. In these situations the soil-forming processes have acted to their full capacity, as governed by their environment. The soils, therefore, have reached a stage of development which is normal for the existing climate and vegetation and are fully developed.

In the Gallatin Valley area differences in elevation, location, and in origin of the soils cause some differences in soil type. Much of the original soil material of this area, according to Peale,[6] was fine volcanic dust, probably wind-borne, which fell upon the surface of the lake then existing and upon the surface of the land. These deposits are termed the "Bozeman lake beds." The present physical character of this material is very similar to the wind-blown or loess material of the Central States. The development of the soil from this material in the southern and eastern parts of the area differs from that in the northern and western parts, although the soils in all parts have developed under a prairie type of vegetation.

The soil types mapped that are considered to have developed, at least in part, from the Bozeman lake beds are Bozeman silt loam, together with its brown phase, Manhattan fine sandy loam, Manhattan very fine sandy loam, shallow phase, Amsterdam silt loam, and Amsterdam very fine sandy loam. These soils are considered nearly normal for this area. The Bozeman soils are darkest in color, and they have also developed a more distinct structure than the lighter colored and sandier textured Amsterdam soils. They are considered normal for their environment.

Following is a description of a profile of the brown phase of Bozeman silt loam, as observed in the SW¼SW¼ sec. 31, T. 2 S., R. 5 E.:

0 to 10 inches, dark grayish-brown silt loam of laminated or fine-granular structure.

10 to 16 inches, light grayish-brown silt loam containing streaks of organic matter. The material is coarsely granular and has an indistinct prismatic structure.

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[6] PEALE, A. C. (See footnote 1.)

16 to 24 inches, structureless noncalcareous light-brown silt loam.
24 to 36 inches, friable and porous gray very fine sandy loam containing light-colored streaks of lime. The material in this layer is very calcareous.
36 to 72 inches, structureless calcareous light grayish-brown very fine sandy loam.

Following is a description of a profile of Amsterdam silt loam, as observed in the NW¼NW¼ sec. 9, T. 2 S., R. 4 E.:

0 to 6 inches, laminated and finely granulated brown silt loam.
6 to 14 inches, coarsely granular and prismatic light yellowish-brown silt loam.
14 to 26 inches, friable and porous gray very fine sandy loam which is very calcareous.
26 to 48 inches, friable and porous light-gray very fine sandy loam containing white streaks of lime.
48 inches+, light-brown moderately calcareous very fine sandy loam.

The profiles described show some contrasting differences in the degree of development that has taken place in the different localities, owing primarily to climatic and vegetational differences in the environment. The darker colored soil at Bozeman has resulted from the greater accumulation of organic matter. A rather distinct structure has also developed, and the depth to the zone of lime accumulation is greatest. The organic accumulation in the Amsterdam soils is much less, and, although some structure has developed, it is not so distinct. The zone of carbonate accumulation is much nearer the surface, indicating considerably less annual precipitation. The Manhattan soils show little structural development because of their sandy texture, and the lime accumulation is at a somewhat greater depth. They are, however, very similar to the sandy Amsterdam soils. Their topographic position indicates a redisposition of similar materials.

The soil of the high bench south of Willow Creek and Three Forks located between the Madison River and Willow Creek drainage basins, which is correlated as Ashuelot gravelly loam, appears to be somewhat older and degraded. A rather large quantity of rounded gravel has been deposited over much of the area together with the lake-bed silts and fine sands. The brown surface soils are granular and somewhat prismatic. They are underlain by gravelly very fine sandy loam. The zone of lime accumulation, lying at a depth of 18 or 20 inches beneath the surface, consists of very fine sand and gravel, which in places are cemented in large blocks, locally called "concrete blocks." These blocks are not everywhere in evidence, but the gravel in this layer are in most places semicemented. The eroded borders of the bench show much cemented development.

The imperfectly developed soils may be divided into subgroups on the basis of the factor or group of factors which have been instrumental in preventing normal development. The first subgroup includes the Bridger and Millville soils, in which sufficient time has not elapsed for normal development.

The darker colored Bridger soils, which have developed in the foothills and mountain slopes, have not developed a discernible structure because of their gravelly or stony character and the prevailing pronounced slope. The slopes are largely colluvial in origin, and are derived from the weathered rock material of the adjacent mountain slopes washed down by rains and intermittent streams. Because of

the greater amount of rainfall and less active oxidation processes in the higher locations, a larger organic accumulation has resulted than in other parts of the valley. The calcium carbonate content has been leached to greater depths, as no distinct lime accumulation is noticeable to a depth of nearly 4 feet. The topsoils are dark brown or black, and they grade into chocolate-brown gravelly compact loam. The subsoil is a mixture of light-brown gneissic sand, angular gravel, and rock.

The Millville soils are probably derived from the same materials as the Bridger soils, but they occur farther down the slope, and structural development has proceeded further. The topsoil is brown or dark-brown silt loam. The subsurface soil, between 8 and 20 inches, is rich-brown silt loam which is friable but somewhat blocky and coarsely granular. The subsoil is brown silt loam irregularly streaked with calcium carbonate and mildly calcareous throughout. The lower subsoil layer, in most places, consists of gravel and fine sands.

In the second subgroup are included the Huffine and Beaverton soils. These are considered second-bottom or old alluvial soils, in which normal development has been prevented by insufficient time and fluctuating water tables resulting from subirrigation.

The surface layers of the Huffine soils are dark-brown laminated silt loam. The subsurface layers consist of moderately compact blocky rich-brown silty clay. This material grades into yellowish-brown friable faintly columnar silty clay loam which, in turn, is underlain by light grayish-brown silt loam streaked with calcium carbonate at a depth ranging from 20 to 30 inches beneath the surface. The material in this layer is moist during the greater part of the year. A gravel stratum underlies much of the area occupied by these soils, at a depth ranging from 2 to 4 feet. This stratum is saturated during parts of the year.

The Beaverton soils are somewhat variable as to development, depending somewhat on the proportion of gravel to soil material. Beaverton loam shows the most complete development of the Beaverton soils, in some places approaching what would be considered a normal soil for the area. The 5- to 9-inch surface layer is medium-brown finely granular loam or heavy loam, which grades into rich-brown coarsely granular heavy loam or silty clay loam, showing a prismatic structure in places. The zone of lime accumulation (light-gray silt loam) lies at a depth of 12 or 15 inches. A gravel substratum is characteristic of most areas, but it occurs at various depths. In the extremely gravelly areas, it may be within a few inches of the surface, whereas in other areas only a few gravel may be present within a depth of 3 feet from the surface. The ground-water level occurs at different depths. In the central part of the area, in the vicinity of Belgrade, the depth to water is great. In the lower ground away from the central area, particularly to the north of Belgrade, ground water may be reached at a slight depth. Since the advent of irrigation, the ground-water level has undoubtedly risen to some extent.

The Gallatin, Minatare, and Havre soils occupy flood-plain positions along streams. They owe their imperfect development both to poor drainage and to recent deposition of the sediments from which they are developing. The moist conditions prevailing in the flood plains have especially favored vegetal growth and decay, and all

soils except those developed from the most recent deposits of alluvium have dark-colored topsoils. The parent materials are so recently deposited that they have not developed into soils having characteristic zones or layers. In many places oxidation and aeration have been retarded by excessive moisture, and in many places the topsoils rest directly on the unweathered or only slightly weathered parent alluvial sediments. The character of the sediments, therefore, is the controlling factor in determining the character of the flood-plain soils.

The Gallatin soils have developed from rather fine sediments, although in some areas enough sandy material has been added to give them a harsh or loamy character. They have dark-brown or black topsoils which are in general noncalcareous. The subsurface material becomes lighter in color, either brown or gray, depending on drainage conditions. The subsoils are gray or mottled gray and brown and are generally calcareous. In many areas they are moist at least a part of the year, depending on the ground-water level.

The Minatare soils are similar in texture, but they occupy a position in the lower part of the valley where a high water table is permanent and evaporation of water from the surface has allowed considerable salt accumulation through the soil and at the surface. The soil color has therefore assumed the color of the salts, at least to some degree.

## SUMMARY


The Gallatin Valley area is situated in southwestern Montana. It includes an area of 802 square miles, or about 30 percent of the land in Gallatin County, and comprises the greater part of the farming land. It occupies a rather high intermountain valley ranging from an elevation of about 4,000 feet above sea level, near the confluence of Gallatin, Madison, and Jefferson Rivers, to nearly 6,000 feet. The nearby mountain peaks rise to a height of about 9,000 feet.

Because of differences in precipitation and terrain, the distribution of the plants comprising the vegetal cover is complex. The more abundant vegetation borders the mountain ranges on the south and east, but this gradually thins out and more drought-resistant species predominate in the western and northwestern parts of the area.

The climate is continental in character and is subject to wide extremes of seasonal and daily temperatures. The mean annual temperature at Bozeman is 41.4° F. and at Three Forks is 42.5°. The average annual precipitation at Bozeman is about 18 inches and at Three Forks is only about 10 inches. The average length of the frost-free season is a little more than 100 days.

The agricultural history of the Gallatin Valley began soon after opening of the mines near Virginia City and in other parts of western Montana. Rapid development, however, did not take place until after the building of the Northern Pacific Railway in 1885. In the early days, livestock raising was the leading pursuit. Within the last 25 years the relationship between the values of livestock and crops produced has been changing. For a number of years wheat has been the most important crop. With the decline in wheat prices, there is a tendency to return to livestock raising.

The soils of this area may be divided into three broad groups, based on their value for agriculture, as follows: Well-drained farming soils, imperfectly drained farming soils, and nonagricultural land.

The dark-colored soils border the Gallatin and Bridger Ranges. The brown soils and light-brown soils extend to the north and west.

Within the area two types of farming are carried on—irrigation farming and dry-land farming. Less than one-half of the land is irrigated. The agriculture of the irrigated areas is largely centered around the production of forage crops (mainly alfalfa) rotated with grains. The farmers in the nonirrigated sections depend almost entirely on the production of wheat. Large areas of untillable land may be used only for grazing.

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# SOIL MAP
GALLATIN VALLEY AREA
MONTANA

MONTANA AGRICULTURAL EXPERIMENT STATION
F. B. LINFIELD, DIRECTOR
WILLIAM DE YOUNG, IN CHARGE DETAIL SURVEYS


Thomas D. Rice, Inspector, District 3.
Soils surveyed by William DeYoung, Montana Agricultural Experiment Station, in charge, and L. H. Smith, U. S. Department of Agriculture.

Scale 1 inch - 1 mile

Field Operations
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1931